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Original Article

A STUDY AND AN ANALYSIS OF MECHANICAL PROPERTIES OF ALUMINIUM ALLOYS AND ITS FIBER COMPOSITES

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ABSTRACT

In the present digital scenario, there has been a wide opening in the research and development of the components such as fiber composite field. This composite fiber field has good formability, wide spread, renewable, cost-effective and eco-friendly features. This research paper sets an outline on aluminium alloys and its composites energized as a part of various commercial and engineering applications. In this paper, illustrations were taken from many articles that supports these applications of natural fiber which reinforced polymer composites. These composites give the fundamental dates' about the usage of natural fibers and its composite materials, mechanical, structural and physical properties. The requirement of light, inexpensive and quickly processed materials has increased to a great extent. The Al/SiC metal matrix composites have light weight, wear confrontation and high elastic modulus. The Al/SiC metal matrix composite has applications in many industries. In the present study, Aluminium based metal matrix composite is primed using stir casting method. The main objective is to evaluate the ultimate tensile strength, hardness and compressive strength of SiC particulate reinforced Al matrix composites as a function of volume of SiC. The specimens made were tested on universal testing machine, Rockwell hardness tester. The effect of weight percentages of SiC in the metal matrix composites on ultimate tensile strength, hardness and the compressive strength is studied.

KEYWORDS: Aluminium Alloy, Composite Materials & Applications

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INTRODUCTION

Overview of Aluminium and its Alloys

The consumption of aluminium deals with the considerable reduction in weight of an automobile body. Aluminium usage in automotive applications has full-fledged substantially in due course of time. There are strong predictions for aluminium applications in hoods, trunk lids and door hangings on a steel frame. As a main point, the material for the engine block, which is a significant part of the automobile sector is switched from the iron cast to aluminium finding in the decrease of weight. A modern car with components made of aluminium alloy can be 24% lighter than one with components made of steel. Today, aluminium is the second most used material (in % terms) of the total weight of the car. It is used to make components of the suspension, the chassis, cylinder blocks and other engine components.

Silicon Carbide

Silicon carbide (SiC), is also stated as Carborundum. It is a mixture of silicon and carbon with chemical formula SiC. It arises in nature as the enormously rare mineral moissanite. Synthetic silicon carbide powder has been highly produced and to utilize as an abrasive. Grains of silicon carbide can be blended together by sintering to shape very hard ceramics that are broadly used in applications requiring high fortitude, such as car brakes, car clutches and ceramic plates in bulletproof vests.

Casting

Casting is an industrialized procedure in which a liquid material is poured into a mold, which employs a void cavity of the preferred shape, and then permitted to solidify. The solidified part is called as a casting, which is evicted or broken out of the mold to finish the process. Casting materials are usually metal or various cold setting materials that treat after mixing two or more components together; examples are epoxy, concrete, plaster and clay. Casting is often used for manufacturing complex shapes because it is difficult or unschooled to make it by other methods.

LITERATURE REVIEW

Mechanical classification of Al/SiC composite is the crack initiation, propagation takes place within a short span. Now a days to overcome this problem, conventional materials are replaced by Aluminium alloy materials. Aluminium alloy materials are found to be the best alternative with its unique capacity of designing the materials to give required properties. In this paper tensile strength experiments have been conducted by a varying mass fraction of SiC with Aluminium based work. It is found that the weight to strength ratio for Aluminium silicon carbide is about three times that of mild steel during a tensile test.

Stir casting process for manufacture of Al-SiC composites [Shahinsoltani, R Azari Khosroshahi] Stir casting is an economical process for the fabrication of aluminium matrix composites. In this study, micron-sized SiC particles were used as reinforcement to fabricate Al-3 wt% SiC composites at two casting temperatures (680 and 850 °C) and stirring periods (2 and 6 min). From microstructural characterizations, it is concluded that the shorter stirring period is required for ceramic incorporation to achieve metal/ceramic bonding at the interface. A higher stirring temperature would lead to a further incorporation of ceramic particles into the molten pure aluminium with an improved distribution.

A Comparative Study on Wear Behaviour of Al6061-6% SiC and Al6061-6% Graphite Composites [Nagaral M, Auradi V et al.]This work investigated the influence of SiC and graphite on the microstructure and wear behavior of Al6061- SiC and Al6061-Graphite composites. The investigation reveals the effectiveness of incorporation of SiC and Graphite in the Al6061 alloy for studying wear properties. The results revealed that Al6061-6% SiC and Al6061-6% Graphite composites were shown more resistance to wear. The wear resistance of Al6061 alloy increased after addition of SiC and graphite particles. The Al6061-6 wt. % graphite composites have shown lower rates of volumetric wear loss as compared to that observed in as cast Al6061 alloy matrix and Al6061-6 wt. % SiC composites.

Preparation of Al 6061/ SiC metal matrix composite (MMc) using stir casting technique [Sharanya Nair et al.]The present research work is about the manufacturing of Aluminium Matrix Composite (AMC) by stir casting technique. In this work, the Stir casting method is the simplest and most economical method to produce quality composite materials. Enhanced mechanical properties of Mg–Al–Zn cast alloy via friction stir processing Mg–Al–Zn casting was subjected to

friction stir processing (FSP) and subsequent aging. FSP resulted in significant breakup and dissolution of the coarse, network-like eutectic b-Mg17Al12 phase distributed at the grain boundaries and remarkable grain refinement, thereby improving significantly the tensile properties of the casting.

Matrix Al-alloys for silicon carbide particle reinforced metal matrix composites [A. Chennakesava Reddy and Essa Zitoun] mechanical properties have been determined for different metal matrix composites produced from Al 6061, Al 6063 and Al 7072 matrix alloys reinforced with silicon carbide particulates. The yield strength, ultimate strength, and ductility of Al/SiC metal matrix composites are in the descending order of Al 6061, Al6063 and Al 7072 matrix alloys. The yield strength, ultimate strength, and ductility of Al/SiC metal matrix composites are in the descending order of Al 6061, Al6063 and Al 7072 matrix alloys.

Kuma and Singh investigated a comparative investigation of mechanical properties of aluminium based hybrid metal matrix composites. The result indicates that there is an increase in the value of tensile strength, ultimate tensile strength, hardness, flexural strength of newly developed composite having SiC and B4C particulates in comparison to the SiC, graphite reinforced composite.

Metallography & Bulk hardness of artificially aged Al 6061-B4C-SiC Stir Cast Hybrid Composites [S. S. Sharma et al.] The Present investigation focuses on the combined effect of B4C nd/SiC on the improvement in the hardness with an average size of 35-40 micrometer on Al 6061 hybrid composites. Due to positive response to an age hardening treatment there is an improvement in the mechanical properties of Al6061 alloy and its hybrid composite.

Al matrix Composite [M. K surappa] 2003 investigated the reinforcement of AMCs could be in the form of continuous/discontinuous fibers, whiskers or particulates, in the volume fractions ranging from a few percent to 70%. Three decades of intensive research have provided a wealth of new scientific knowledge on the intrinsic and extrinsic effect of ceramic reinforcement vis-à-vis physical, mechanical, thermo mechanical and tribological properties of AMCs.

ALUMINIUM METAL MATRIX

AL 6061/SiC

Table 1: Chemical Composition of Al6061/SiCMatrix

Component	Amount(% Wt)
Aluminium	88.95
Magnesium	1.2
Silicon	0.8
Iron	0.7
Copper	0.40
Zinc	0.25
Titanium	0.15
Manganese	0.15
Chromium	0.35
SiC	7
Others	0.05

Properties of Al 6061/SiC

The practice of Al-SiC Metal Matrix Composites is continuously growing in the last years due to their distinctive properties such as, light weight, high strength, high explicit modulus, high exhaustion power, high hardness, low density,

increased tensile strength, increased compressive strength and increased hardness and materials appeared to have smaller values for total displacement and total energy during impact testing.

Method of Forming

Aluminium got 99.8 in wt. %, which is used as a matrix. Micron-sized SiC particle with a standard particle size of 80 µm and 99.9 % clarity are taken as a report for strengthening of metal matrix composite. The morphology of the silicon carbide particles is used to focus on the SEM micrographs.

Figure 1: Casting Process

To ensure and formulate the composites, one gram of reinforcement SiC powder is condensed carefully in an aluminium foil packet for corral the molten aluminium is further fabricated with 7 wt. % SiC as reinforcement. These powders are once again pre-heated at 350 °C for 4 hours, but before the casting procedure eliminate the humidity and impurity.

The unadulterated aluminium is heated at the temperature of 600 to 680°C within a bottom-pouring furnace. A pre-heated graphite agitator is placed at the bottom of the surface to melt and rotate with a speed of 500 rpm and at the same time as an argon with a high sanitation is used as a shielding cover on the melt surface. Magnesium acts like a surfactant power that acquire oxygen. The magnesium reacts with alumina to form MgAl2O4 at the interface Al/SiC, as shown by the following reactions:

3 Mg (l) + Al2O3 (s) → MgO (s) + 2Al (l)

3 Mg (l) + 4 Al2O3 (s) → 3 MgAl2O4 (s) + 2Al (l)

Initially, a lower casting period is sensibly chosen. Secondly, the reaction experience between matrix and reinforcement might need a long revelation time, that this unfavorable phenomenon might be avoided using a lower amount of stirring time. Thirdly, higher casting period may lead to the entrance of a higher amount of sponginess after the solidification.

Hence, sample, for example, is designed in this study to investigate the further stirring after particle feeding. The sample is prepared for metallographic examinations using 220-320-500-1000 mesh emery papers, pursued by purification with diamond paste 1µm. Microscopic methods are used to study the composite structure and fracture surface using two kinds of scanning electron microscopes (SEM, Cam Scan Mv2300, equipped with EDAX analysis and SEM, KYKY-EM3200), and an optical microscope (OM). A high-resolution diffusion electron microscope (HRTEM, Philips CM200) at an accelerating voltage of 200 kV is confronted for the research.

Hardness tests were conducted in accordance to ASTM E384 using an applied load of 100g for a 15s duration. At least ten measurements were taken from fabricated samples. Tensile specimens are prepared from the cast composites. All of the tensile tests are also executed at the room temperature using a universal testing machine operating at a stable rate of crosshead displacement, with an preliminary strain rate of 2×10-3s-1. The 0.2% proof strength (interpreted as the measurable YS), UTS and ductility (% elongation to break) are measured and averaged over the test samples. In order to control the onset reaction temperature between pure aluminium and SiC powders, inconsistency scanning calorimetric (DSC) analysis is used. For this reason, a comparable weight of aluminium and SiC powders are mixed for 30 min using a low-energy ball-mill to make an apt contrast between them and break the probable oxide layer on the aluminium surface, and the milled powders are then heated from 25 to 800 °C with the heating rate of 10 °C/min using pure argon ambiance and alumina crucible.

RESULTS AND DISCUSSIONS

Testing

The Al6061/SiC metal matrix has subjected to the following tests to study the characteristically the behaviour of the composite.

Hardness Test

The Rockwell hardness test is conducted on the specimen and the following results were obtained in the Al6061/SiC metal matrix.

Rockwell Hardness:

64.5, 60.1, 64.1 & 67.0 HR15T

Tensile Test

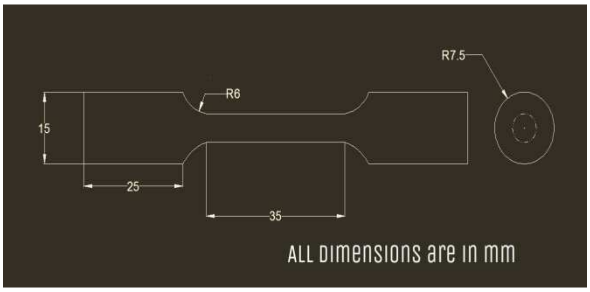

Figure 2: Standard Dimension

The specimen is now subjected to tensile test on the universal testing machine with the prescribed dimension.

Figure 3: Specimen before Testing

Figure 4: Specimen after Testing

The obtained ultimate tensile strength is **109.39 N/mm^2.**

Compressive Test

The compression test for the specimen was conducted for the specimen at the standard Dimension.

Figure 5: Standard Dimension

Figure 6: Specimen before testing

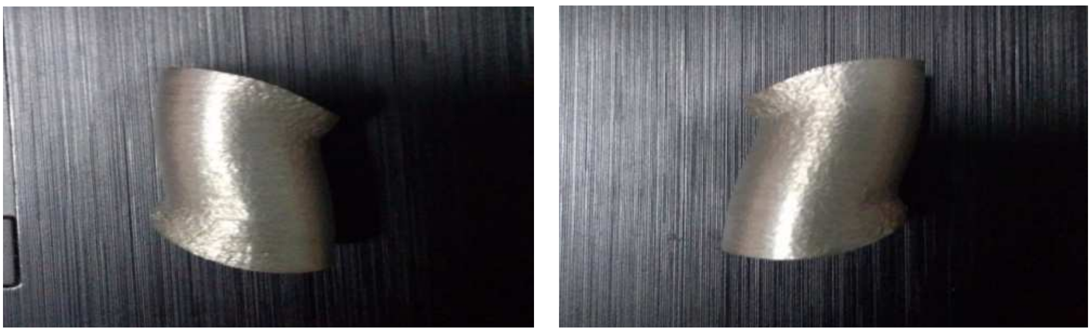

Figure 7: Specimen after Testing

The obtained ultimate compression strength is **219.802 N/mm^2.**

TEST REPORT

Table 2

Input Parameters			Output Results		
Sr.No.	:	Balaji Tensile	Ultimate Load (kN)	:	2.57
Specimen Diameter (mm)	:	5.47	Ult. Tensile Strength (N/mm^2)	:	109.319
Final Diameter (mm)	:	5.19	Disp. At Ult. Load (mm)	:	2.31
Cross Section Area (mm^2)	:	23.509	Breaking Load (kN)	:	1.39
Test Temp	:	1345	Breaking Stress (N/mm^2)	:	59.126
Test Speed (mm / min)	:	2.00	Maximum Displacement (mm)	:	2.73
Original Gauge Length(mm)	:	30.00	% Elongation (%)	:	4.399999
Final Gauge Length(mm)	:	31.32	% Reduction in Area (%)	:	9.98
			Yield Load (kN)	:	0.000

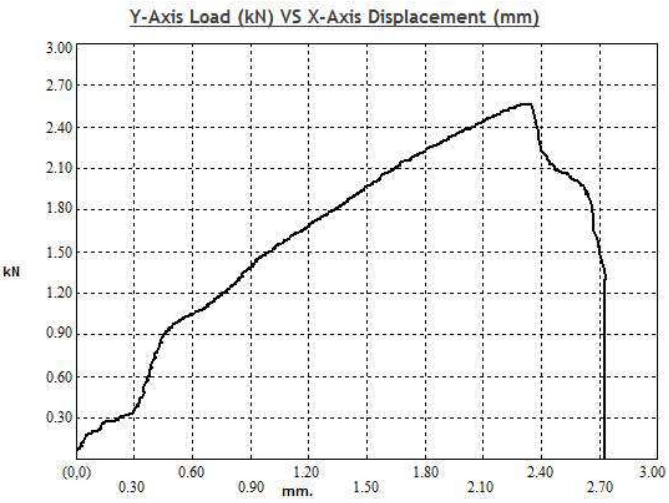

Figure 8

Tensile Test

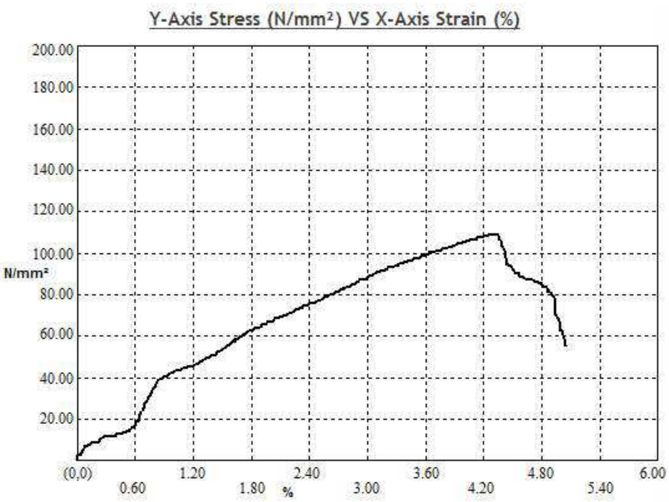

Figure 9

Compression Test

Table 3

Input Parameters			Output Results		
Sr.No.	:	Balaji Compressio	Ultimate Load (kN)	:	38.29
Specimen Diameter (mm)	:	14.89	Ult. Compression Strength (N/mm²)	:	219.802
Final Diameter (mm)	:	18.46	Disp. At Ult. Load (mm)	:	5.77
Cross Section Area (mm²)	:	174.202	Breaking Load (kN)	:	19.39
Test Temp	:	1345	Breaking Stress (N/mm²)	:	111.307
Test Speed (mm / min)	:	2.00	Maximum Displacement (mm)	:	10.56
Original Gauge Length(mm)	:	35.29	% Elongation (%)	:	-28.98839
Final Gauge Length(mm)	:	25.06	% Reduction In Area (%)	:	-53.70
			Yield Load (kN)	:	23.820

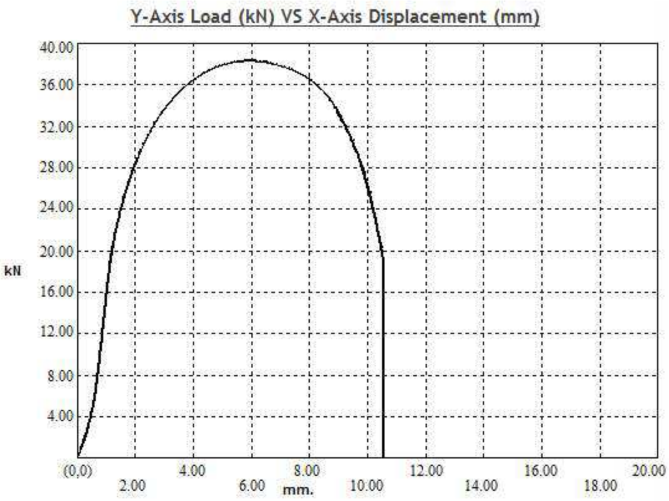

Figure 10

Rockwell Hardness

64.5, 60.1, 64.1 & 67.0 HR15T

THE COMPARISON

Table 4: Comparison and Result

DESCRIPTION	AL6061	AL6061/SiC	JOURNAL
Tensile Stress(N/Mm^2)	102	109.379	81
Hardness (Hrb)	60	67.1	63
Elongation (%)	8	4.33	4.0
Compressive Strength(N/Mm^2)	150	219.802	193.47

CONCLUSIONS

To sum up, the fuel consumption in automobiles can be condensed by declining its weight due to which CO2 emissions can be reduced. Thus, considerable efforts are being made to replace steel with other new promising and more efficient materials. Among these new materials, aluminium alloys are more effective to replace steel due to its promising properties. The findings on the work is that the weight of the strength ratio for Aluminium silicon carbide is about three times that of mild steel during a tensile test. Aluminium silicon carbide alloy composite material is two times less in weight than the aluminium of the same dimensions. This designates that the Aluminium silicon carbide composite material is having less weight and more strength and it is very much useful in the practical applications and industrial revolutions for the present scenario.

- Casting of AA6061/SiC/10p can be done by stir casting process.
- Hardness and tensile strength increases by the reinforcement of SiC into the aluminium matrix.
- For casting of composite by stir casting process stirring speed, temperature, time, reinforcement preheat temperature, particle incorporation rate, are the important process parameters.
- Ultimate Tensile Strength is increased with the increase in the silicon absorption of the composite.
- Hardness increases with the increased in concentration of silicon carbide but sometimes decreases due to absorbency occur during casting.
- Strength and hardness increase in case of MMC but ductility decreases.

The result of investigation on the effect of SiC on mechanical properties of AA6061 aluminum alloy composite provides the following observations:

- Stirrer design play a crucial role in the vortex formation and overall soundness of casting, therefore different stirrer designs can be used for casting.
- Few more concentration must be used in future which helps us in finding more accurate results.

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